

**In this Issue:**

Welcome article	1
TFSG Student Bursaries	1
Early Career Reports	2
Future TFSG Events	3
50 <sup>th</sup> Anniversary of TFSG Formation	4
Solid Surfaces Group Symposium	4
10 <sup>th</sup> Vacuum Symposium	4
Surface Science Day 4	5
TFSG-relevant Facilities	5
Researcher Profile	6
TFSG Committee	7

### Welcome

Welcome to the Spring 2020 edition of the IOP Thin Films and Surfaces Group which I imagine many of you are reading from home as Covid-19 impacts the way in which we all behave, work and study.

The challenges posed to the community as a whole are wide ranging and indeed the impact on the science sector continues to provide new challenges and uncertainties as we move towards a new way of living, studying and working with these impacts being of variable durations and some possibly permanent. This has been emphasised through a number of topics of concern fed back to the IOP by the committee with regards to student support, the

impact on academic institutions and ongoing research.

As I am sure many of you are aware a number of TFSG and other IOP group meetings and conferences have been delayed or cancelled as can be seen from the Events listing for TFSG on this newsletter but also for the IOP as a whole. As part of mitigating the impact of cancelled events and continuation of future events several discussions are underway across groups and the IOP to understand if virtual events and formats are possible, I have indeed been involved with several new types of events including an online exhibition event.

This newsletter includes reports on the vacuum science symposium held in October, the Surface

Science Day in December and the 50<sup>th</sup> Anniversary of the TFSG formation reported on page 4.



Additionally, the committee is keen to hear how we can further support our community. Please do get in touch if you have suggestions, would like to contribute an article to the newsletter, or otherwise get involved.

Best wishes,

Dr Steven Stanley  
*Light Coatings Ltd*

### TSFG Student and Early Career Bursaries

*The Institute of Physics (IoP) provides financial support to research students to attend international meetings and major national meetings.*

Research Student Conference Fund (RSCF) bursaries\* are available to PhD students who are a member of the Institute and of an appropriate Institute group. Students may apply for up to **£300** during the course of their PhD and may apply more than once, for example they may request the full amount or decide to request a smaller amount and then apply for funding again for another conference at a later stage.

Note that grants will normally cover only part of the expenses incurred in attending a conference and are intended to supplement grants from other sources. All recipients are asked to produce a report on return from their conference before receiving payment. For details and application form please look at [http://www.iop.org/about/grants/travel-bursaries/page\\_69141.html](http://www.iop.org/about/grants/travel-bursaries/page_69141.html).

\* Please note that bursaries are not available for meetings organised by the Institute of Physics including those organised by IOP Groups.

## Early Career Reports

### APS Meeting, Boston, USA, 4-8 March 2019

The highlight of the conference for me was an invited talk by Prof. Nadya Mason from the University of Illinois at Urbana-Champaign, in a session titled “*Topological Materials – Mesoscopic and Novel Probes*”. She gave an incredibly inspiring talk about her work on Aharonov-Bohm oscillations in topological insulator nano-ribbons and Fraunhofer spectroscopy in superconducting Josephson junctions.

I also attended many other useful talks, in particular by members of the Dean group at Columbia University. I had not come across their work before, but they are experts at fabricating multilayer graphene devices which is similar to my project of fabricating multilayer topological insulator devices. Their talks gave me new inspiration of different geometries it would be interesting to try. I also went to a number of talks by members of the Samarth group and the Chang group at Penn State university who are working on magnetic topological insulators.

My talk was well received and I spoke to a number of people afterwards from NIST, University of California Riverside and University of Maryland who were interested in my work and wanted to keep in touch and carry on discussions. It was also useful that our collaborators from MIT were at the conference, as we were able to discuss our work in more detail and come up with further plans for the next few months.

Overall, I think the conference was very successful. There was a lot going on at any one time, so it was difficult to attend everything I was interested in, but I found it very rewarding. It was an exciting time to attend, as I am finishing my PhD and looking for inspiration for the next steps in my career.

Ankita Anirban  
*PhD student, University of Cambridge*

### CLEO-EQEC, Munich, Germany, 2019

These notes summarise both talks attended by myself during the conference, as well as private, informal interactions with other attendees and finally personal impressions.

Highlights: A great emphasis was given to both the areas of quantum sensing, with a range of talks about

techniques ranging from magnetometry to photoluminescence, as well as computational photonics, even if mostly intended as classical, which are both of particular interest to me.

A well-attended award ceremony featured talks from (i) Zeilinger, University of Vienna, about high-d entanglement, automated experiment generation (mainly the papers with M. Krenn), the free-choice of setups for quantum experiments and the “human Bell test”, and (ii) Knight, Imperial College, about quantum non-demolition measurements in cavities, the exploitation of Ramsey phase shift effects and historical S. Laroche’s experiments

An interesting talk about fs-laser written circuits from A. Crespi, Politecnico di Milano, emphasized the latest achievements of this platform, such as LiNb propagation losses of 1 dB/cm, achievement of path+polarisation entanglement and fringe visibilities of about 94.5%, but also some of its limitations such as phase shifters requiring 300mW @  $2\pi\pi$ , polarization control hard to achieve, chip-to-chip bonding still ongoing.

A talk far from my experience but well-structured was Eggleton’s, University of Sydney, about hypersound photonics, or according to his own labeling, “phoxonics”. He stressed the difficulties in material choices ( $As_2S_3$  is an exotic example) and design for GHz-phonons, discussing light-matter interactions in this realm, stimulated Brillouin scattering and radiation pressure phenomena. Technologically, he displayed impressive filtering capabilities for such phonons with bandwidth  $> 10$  GHz and 50 dB extinction, as well as the seminal idea to use phononic waveguides as memories.

Personal benefits: I was able to present the magnetometry protocol recently developed and tested in Bristol University, based upon Ramsey interferometry [[PRX 2019](#)]. The talk was fairly well attended considering the early morning slot, but unfortunately the session was rather broad, so that the audience could only develop a generic interest in the approach, without appreciating technical details.

During my stay in Germany I was able to interact productively with (i) The group of Prof. Jelezko, discussing future developments of the recent collaboration that led to the publication of the paper presented at the conference, inclusive of more extensive, online experimental testing in the near future, and (ii) Members from Degen’s group, ETH, discussing the group’s recent developments in the fabrication of ab.

5 mm NV-centre-loaded tips on top of AFM cantilevers via gluing [[Nano Lett 2017](#)]. These probes are now commercially available via the start-up QZABRE. They used these methods to investigate spintronic devices and quantum sensing of waveforms [Zones et al. in preparation].

Antonio A. Gentile  
*PhD student, University of Bristol*

### MRS Spring Meeting, Phoenix, USA, 2019

I visited Phoenix to attend the MRS Spring Exhibition 2019 from 22-26<sup>th</sup> April. Phoenix is a very different place; it was hot, dry and with lots of sunshine. The conference started on Easter Monday with some symposiums but most of them started on Tuesday.

During the conference, I attended a range of symposiums. My current field of research is about predicting and studies solid-solid interface structures. There were dedicated sessions to theoretical/model system study of interface/grain boundaries, energy generation and storage materials, where interfaces are often the limiting factors, sessions focus on materials discovery and data mining as well as quantum oxide thin film materials. I had to choose between these sessions and sometimes make difficult decisions.

The plenary sessions were also interesting. There was a talk by Helena Van Swygenhoven-Moens from EPFL highlighting the time resolution of synchrotron light source to material research and in operando measurements.



*PhD student, Bonan Zhu, at the MRS Frontiers Reception social event*

My oral presentation about structures of the STO-CeO<sub>2</sub> interface was also a success and attracted interests in the audience. I had a discussion with an experiment about confirming the structure search result though X-ray methods. I also met researchers from the Arizona State University (Peter Crozier's group) who are doing research about CeO<sub>2</sub> grain boundaries with both computational and electron microscopy approaches.

The poster session gave me a chance to see more works of other researches of the field and have discussions with them. It also gave me a glimpse of the field that I am less familiar with. I had some interesting discussion with post authors about microscopy techniques, structure searching and 2D materials.

The conference also had a range of social events such as Students Receptions and Frontiers Reception: Building Communities. I networked with people with different field of research and exchanged contacts. Perhaps collaborations can be formed in the future.

Overall, I think the conference was a success. It gave me a larger view of the materials research, which would help me to choose my career in the future. There are also people doing similar research about interfaces and oxide materials as I do, and I made good use of the time there to discuss and ask them questions.

Bonan Zhu  
*PhD student, University of Cambridge*

### FUTURE EVENTS

- **May 18<sup>th</sup>:** [HP-XPS-EM4](#) (POSTPONED)
- **Jun 12<sup>th</sup>:** [Interfacial Characterisation of Electrochemical Energy Conversion and Storage Devices](#), Manchester (POSTPONED)
- **Jul 20-22<sup>nd</sup>:** [UK Colloids 2020](#), Liverpool (POSTPONED).
- **Jul 27<sup>th</sup>:** [Nanoscience@Surfaces](#) summer school, Liverpool (CANCELLED)
- **Sept 22<sup>nd</sup>:** [Ions and Plasma in Structuring of Surfaces and Thin Films](#), London (MOVED to June 9<sup>th</sup>, 2021)
- **Sept 23<sup>rd</sup>:** [Advances in Photovoltaics](#), London (POSTPONED)
- **Dec 18<sup>th</sup>:** Surface Science Day 5, Leeds

## 50<sup>th</sup> Anniversary of TFSG Formation – Report

On 21<sup>st</sup> November 2019, the Thin Films and Surfaces Group marked its [50<sup>th</sup> Anniversary](#) at a celebratory event at the new Institute of Physics headquarters at King's Cross in London. We enjoyed two excellent talks from Iggy McGovern (Fellow Emeritus in Physics, Trinity College, Dublin) and Robert Jones (Emeritus Professor, University of Nottingham), followed by drinks amongst the assembled members.

The talks focussed on the development of our field over that five-decade period and really captured the evolution of both the science and technology. As a comparative newcomer to the field, I found it amazing to reflect on the changes that have taken place. Iggy managed to convey a real impression of life during the early years of the development of surface science in his talk, which was also interspersed with the occasional reading of his poetry. Robert further expanded upon the sense of continuous development and drive to understanding more and more complex problems.

The TFSG has seen the field move from early glass vacuum systems with getter pumps to modern turbopumped stainless-steel vessels, has led the development of now ubiquitous techniques like STM, and research using synchrotron radiation. Along the way, the field was completely revolutionised by the emergence of automation and computers. It was also clear how much the basic culture of research has shifted, moving from home-built apparatus to commercially available, integrated and automated instruments. Scientifically, the field has developed from needing to understand the most basic behaviour of atoms at surfaces - which is now treated as fundamental to much modern of science - to more and more complex materials in progressively more diverse applications. Looking forwards, it will certainly be exciting to see where the next decades take us!

Dr Andrew Jardine  
*University of Cambridge*

## Solid Surfaces Group (SSG) symposium – Report

On Friday 17<sup>th</sup> January 2020 the solid surface group (SSG) of the Royal society of Chemistry (RSC) held its annual symposium at Burlington House in Lon-

don. This one-day event had a particular focus on ultra-fast measurement techniques used in surface science experiments. The meeting was attended by 48 delegates and had invited presentations from Dr Andrew Jardine (University of Cambridge); Dr Jan-Gerrit Horstmann (Georg August Universität Göttingen); and Dr Thomas Buchner (Universität Regensburg).

Dr Jardine described his group's research into the development of helium spin echo spectroscopy to study picosecond dynamics at the nanoscale. Dr Horstmann, a postdoctoral researcher in the group of Prof Claus Ropers, presented recent advances in the Ropers group on the use of ultrafast low energy electron diffraction (LEED) to observe and control structural phase transitions at surfaces. Finally, Dr Buchner, a postdoctoral researcher in the group of Prof Jascha Repp reported on the development of THz scanning tunnelling microscopy (STM) to study single-molecule switches at femtosecond timescales.

In addition to these three invited speakers a number of other talks and posters were presented by PhD students and PDRAs from several UK based research groups. These presentations covered a broad range of topics from resonant photoemission at near ambient pressures to organic electron acceptors at Au(111) interfaces. The organisers of the meeting were grateful for sponsorship from the Thin Films and Surfaces Group of the Institute of Physics (IoP), Scanwel Ltd; Hiden Analytical Ltd and SPECS GmbH.

Dr Matthew Blunt  
*Secretary SSG*

## Vacuum Symposium – Report

The [10<sup>th</sup> Anniversary Vacuum Symposium](#) (VS10) was held on 9-10<sup>th</sup> October 2019. VS10 comprised 5 technical meetings and 7 vacuum training courses, co-located with an exhibition of vacuum equipment and supplies (Vacuum Expo). This annual event attracts a great variety of academia and industry and promotes a great willingness to share knowledge, ideas and experiences amongst the participants.

Of particular interest to TFSG was the "Thin Film and Coating Technologies for Science & Industry" Meeting held in a sectioned off area in the Vacuum Expo arena. Attendees were able to drift in and out of the different talks whilst not being too far from the exhibition.

Keynote speaker Prof. Hazel Assender from the University of Oxford gave an interesting talk on “In-line patterned vacuum R2R coated layers for flexible electronics.” By using flexography printing apparatus retrofitted to a commercial roll-to-roll vapour deposition system, Hazel’s group have demonstrated, through oil masking, R2R in-line patterning of metals with line widths down to 50  $\mu\text{m}$ , producing 37 nm thick Al electrodes on flexible PET substrates at 25m  $\text{min}^{-1}$ .

Phil Hollis from CPI also gave a presentation on R2R technologies, but on “Thin-film Atomic Layer Deposition (ALD): a large-scale deposition process towards industrial applications”. CPI have both batch and roll-to-roll format ALD tools available. Phil provided many different applications from high k-dielectrics for micro-electronics through to more industrial films for gaseous barriers, protective and active layers in larger area electronics, displays and battery applications on both rigid and flexible substrates which they have shown to have promising results.

An EngD student from the University of Surrey, Beaujolais Bussell, presented her work on “Oblique angle deposition of AZO”, depositing world leading resistivities of AZO with the Plasma Quest sputtering technology at room temperature,  $\rho \sim 3 \times 10^{-4} \Omega \cdot \text{cm}$

John Whiteman from Plessey Semiconductors Ltd gave a fascinating talk on their microLED development. The precision of their wafer to wafer bonding process is astounding, and how small they have managed to reduce the pixel pitch, 3  $\mu\text{m}$ , is very impressive. A very exciting technology for HUD and AR glasses. Plessey Semiconductors are a company to keep an eye on in the future.

Dr Steve Shannon, *SS Scientific*, and  
Dr Hayley Brown, *Plasmaquest*

## Surface Science Day 4 – Report

The fourth [Surface Science Day](#) was held in Manchester in the Photon Science Institute and Alan Turing Building on 16<sup>th</sup> Dec. 2019, sponsored by the Thin Films and Surfaces Group of the IOP, Kratos, Scanwel, Scienta Omicron and Henniker. The event was well attended with delegates from across the UK, representing a broad range of surface science research. There were a couple of hiccups at the beginning of the day with the original room being double

booked and the loss of two speakers with noravirus, but this didn’t spoil the science that followed.

The programme covered a range of topics from peptide gels through biosensing to nanoscale manipulation and the investigation of polymer and carbon surfaces. The student/early career poster session drew around 30 posters which were of a very high standard and highlighted the vibrancy and breadth of UK surface science research in the 21<sup>st</sup> century. Two poster prizes were awarded to students for their presentations: The runner up was Marco Turano and the winner was Stefania Moro, both from Giovanni Costantini’s group in Warwick.

The organisers would like to thank the sponsors once again and of course all of the speakers and delegates who make these events a success. Prof Sven Schroeder of Leeds agreed to host the next meeting in late December 2020.

Dr Andrew Thomas  
*University of Manchester*

## Facilities relevant to TFSG

Access to computational facilities for researchers, who would like to perform scientific modelling as part of their work on thin films and surfaces is available via the Hartree Centre. There are various access routes to High Performance Computing (HPC) as follows:

- ARCHER driving test, which allows those new to HPC facilities demonstrate that they are sufficiently familiar to use the machine effectively. On successful completion of the driving test, you will be invited to apply for an account on ARCHER and awarded 1200 kAUs/80,000 core hours over a period of twelve months.
- ARCHER instant access, for a limited number of core hours over a six-month period. This mode of access should give new users the opportunity to test ARCHER for their purposes and work towards a fully peer reviewed application either via a standard grant or via the RAP.
- ARCHER access through research grants either via EPSRC or other funding bodies.
- ARCHER access through calls for proposals to the RAP. Meetings are held three times a year. A reasonable number of core hours should be requested for a maximum time of one year. The aim of these

calls is to provide access to the National HPC Service for proposals of high scientific quality that would benefit from ARCHER independently from its feasibility for a standard grant application.

- ARCHER access through the Leadership Call, published on the EPSRC-Calls webpage approximately every 9 months. The aim of these calls is to provide access for computationally intensive individual projects of high potential impact. Applicants from academic and non-academic research groups can apply for more than 100,000 kAU for a maximum of 24 months.

For further information, please follow the next link on the EPSRC webpage: <https://epsrc.ukri.org/research/facilities/hpc/access/routes/>

Dr Theodoros Papadopoulos  
*University of Chester*

### Researcher Profile

Having gained a BSc (hons) in Physics from the University of Surrey in 2017, I knew I wanted to pursue a career where I could apply my knowledge to something that really makes a positive difference to the world. Having always had an interest in the applied areas of physics such as nanotechnology and materials science, I secured an EngD position in the MiNMaT (Micro- and Nano- Materials and Technologies) CDT at Surrey, in collaboration with Plasma Quest Ltd, a developer of novel sputtering systems and advanced thin films. The technology is a patented remote plasma sputtering tool that can deposit a range of materials including ceramics and magnets. My research focuses on using this to deposit aluminium zinc oxide (AZO), a transparent and conductive thin film that has various uses in optoelectronics, such as sensors and photovoltaics. AZO is of interest as a major sustainable replacement to the more commonly known, Indium Tin Oxide (ITO).

Unlike a traditional academic PhD, an Engineering Doctorate (EngD) is classed as a professional doctorate and is partially funded by the collaborating company. This means that on a day-to-day basis I work full time at my sponsor's site, visiting the university every other week to perform materials characterisation using their surface analysis facilities, such as X-ray Diffraction and X-ray Photoelectron Spectroscopy. Being a professional qualification,

this also means that I've had the opportunity to develop my communication and managerial skills. For instance, I have gained a CMI Level 3 Certificate in Principles of Leadership and Management, attended both academic and industrial conferences, undertaken a course on digital communication (23 Things) and have taken part in outreach activities at local schools to encourage the younger generation to follow a career in STEM.



*Beaujolais Bussell, University of Surrey*

What I love about the field of thin films is its multidisciplinary culture - with researchers originating from all over the sciences. Biologists, chemists, engineers and physicists come together to apply their respective knowledge to all sorts of new and exciting inventions that get used across the whole of society. At Plasma Quest Ltd alone we have been exposed to a range of thin film applications through our clients, from photovoltaics to smart windows and iridescent coatings based on designs from the natural world. Commercialising new discoveries is also at the heart of business and innovation. I have been lucky enough to contribute to the development of 2 new patents whilst studying for my EngD, as well as the opportunity to shadow a Patent Attorney for 1 week at an IP firm in Guildford.

With access to the full suite of facilities at the university, I have been able to advance my

knowledge in a range of topics, by undertaking a series of technical short courses in engineering and sustainability. Within the Centre for Environment and Sustainability (CES) and the Centre for the Understanding of Sustainable Prosperity (CUSP), I undertook courses on Life Cycle Assessment and Ecological Economics respectively. These exposed me to a completely different way of thinking and provided me with lots of inspiration for my research. I am particularly keen to advance and promote the collaboration of manufacturing and engineering industries with these fields, as I firmly believe circular thinking should be at the forefront of planning for the future.

I hope I have demonstrated that whether you're studying for, or thinking of studying for an EngD/ PhD, a doctorate is what you make of it. It can provide you with a wealth of new experiences and opportunities in areas that you never would have thought possible, allowing you to grow both personally and professionally. Whilst it may prove difficult at times, there is nothing more satisfying than knowing you're collaborating on something special.

In my spare time I enjoy sailing and recently bought my first dinghy which is kept in the Solent. I also like to get outside for walks in my surrounding countryside, which my Sprocker Spaniel loves too!

Beaujolais Bussell  
*University of Surrey*

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<http://tfsg.iop.org>

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## **TFSG Committee**

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Dr Sebastian Wood - National Physical Laboratory  
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